

# Low-cost Gyroscope Research -aka- Autonomous Navigation System (ANS) for General Aviation

**A Cooperative Research Activity between  
the Federal Aviation Administration and  
the University of Alabama, et. al.**

**Jim Branstetter, AAR-210**

**Mitch Narins, AND-705**

# State of Future NAS Operations

- **Nat'l Airspace Sys is moving towards implementing GPS as replacement for existing navigation & landing aids**
- **Current “stand-alone” GPS procedures are not acceptable without a backup capability (Volpe)**
- **Currently no acceptable backup system exists that meets the cost or accuracy requirements for GA**

# GPS Risk Assessment Report

- Volpe conducted study - Oct. 2001 Public Briefing
- Issued in response to multiple agency concerns, from JHU report, offered recommendations
- Bottom line: (sole source navigation via GPS) “vulnerability can be reduced but not fully eliminated”
- “augmentations important for integrity, but do not eliminate possibility for disruptions”
- “independent backup procedures or *systems* essential in critical civil transportation uses”
- view @ <http://www.navcen.uscg.gov>

# Background - project investment

- Congressional Earmarks (FY-99, -00, -01) for “Low-cost” precision gyroscope R&D
- Challenge: provide a useful product for FAA and aviation community
- Key Result: Low-cost INS capability to augment GPS for General Aviation
- Potential new “Autonomous Navigation” Program to aid future flight operations in the NAS

# GA need for advanced sensors

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- **Future airspace - aircraft mix (GA with airlines) in common airspace will dictate improved navigation accuracy**
- **Current trends/advanced cockpits req't: autonomy, "free-flight", ADS-B**
- **Existing technology - less accurate, not capable of data output to drive new FMS, moving map displays**

# GA “niche” market

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- low-cost requirement
- high accuracy requirement for long term navigation
- small market whether for new or retrofit aircraft

# State of Sensor Technology

- **Current INS use Ring Laser Gyros**
  - navigation grade (high) accuracy
  - very expensive, used only by airlines/military
- **Sensor development focus by DoD:**
  - weapons grade (low accuracy, low cost)
  - precision navigation (high accuracy, high cost)
  - specialized packaging requirements
- **Sensor development focus by auto industry:**
  - low accuracy for aviation concerns
  - high volume = millions of \$ in R&D

# FAA sponsored ANS activities

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- UA low-cost gyro research and development (3rd year)
- SBIR (Phase 1) investigations
- NAS Study - BAE Systems
- GPS/INS Integration Study - OUAEC



# University of Alabama - R&D

- **Develop low-cost / high-accuracy gyroscopic sensors for Gen Av market**
  - Principal Investigator: Dr. John Jackson
- **Micro.Electro.Mechanical Systems (MEMS)**
  - Dr. R.K. Pandey
- **Interferometric Fiber Optic Gyro (IFOG)**
  - Dr. A. Malam (UA-Huntsville)
- **Supporting electronic systems, simulation testing and prototyping**
  - Dr. Alton Highsmith

# U A Research Facilities

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- MEMS fabrication laboratory/clean room
- Computer simulation facility
- Gyroscope analysis laboratory
- Electronics package development lab

# UA “macro-MEMS” design

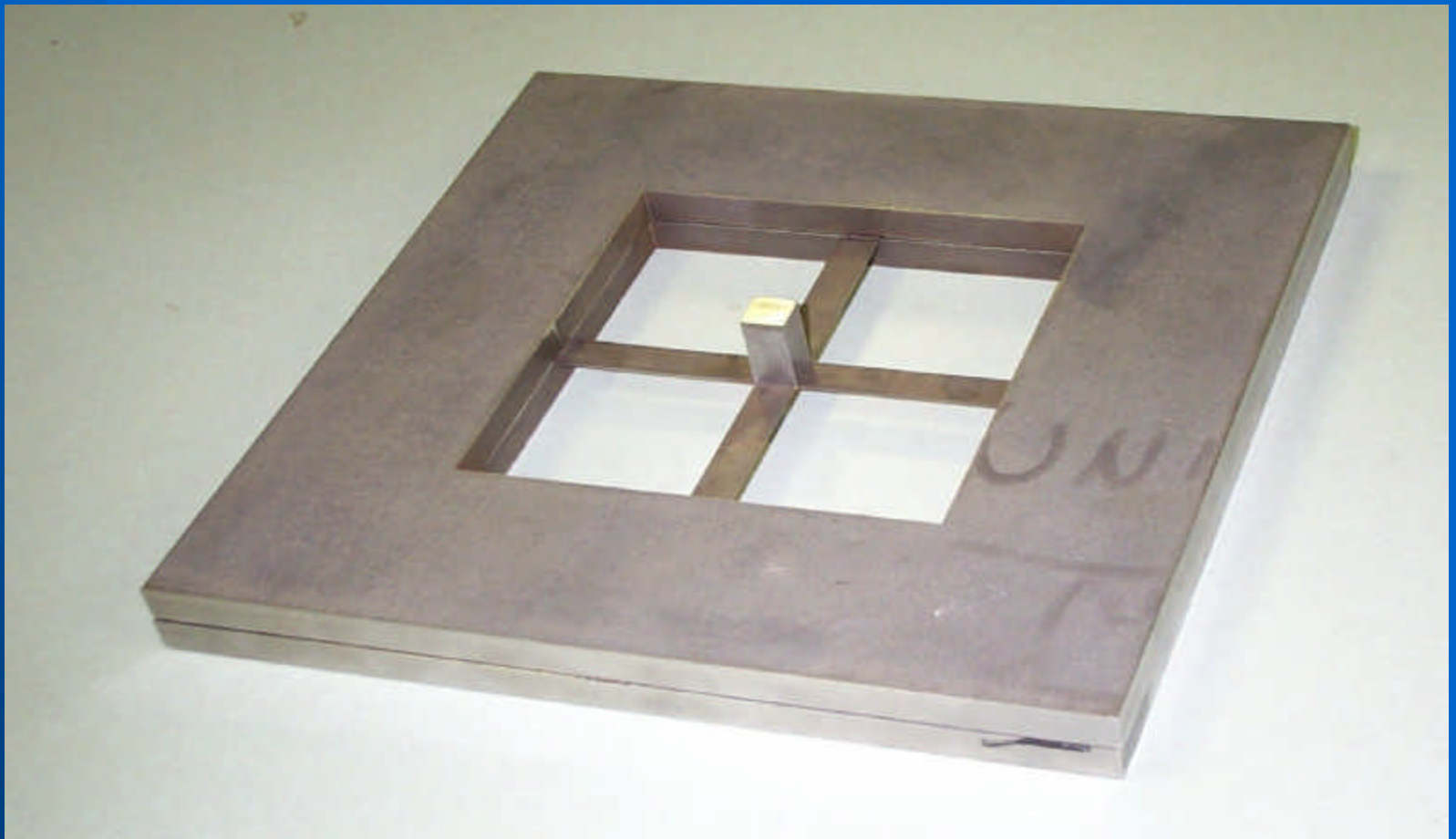
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- Based on initial design work by military and industry
- Studying specialized materials and coating techniques
- Cooperative Agreements with Army:
  - Redstone for wafer design and
  - ARL for PZT coatings

UA MEMS Technology

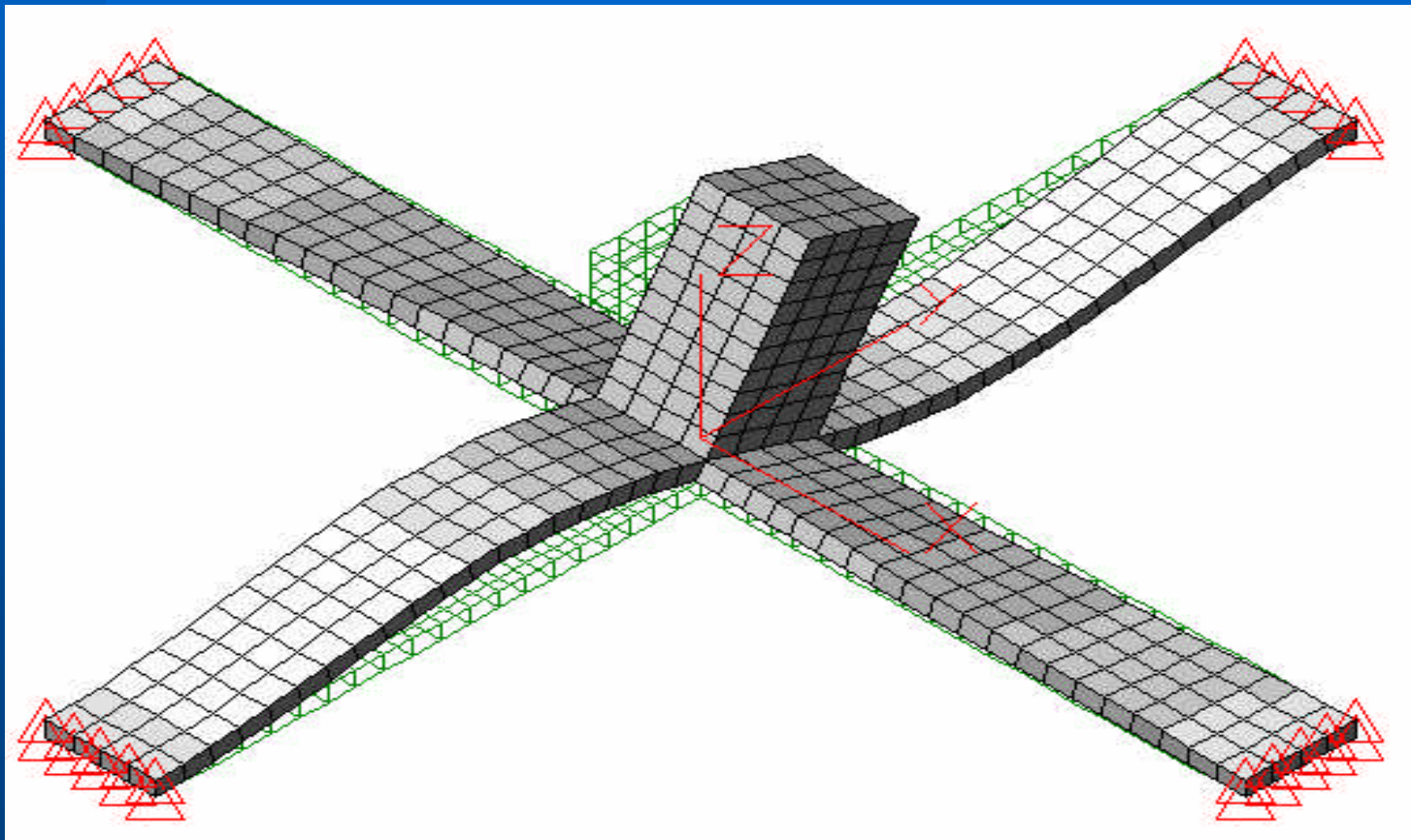
# Meso-scale X-Post Gyro

(10X Mockup)



# Finite Element Analysis of X-Post Gyro

## first asymmetric bending mode



# UA, MEMS activities with DoD

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- **Redstone Arsenal (AMCOM)**
  - MEMS prototype development -  
Dr. Paul Ashley
- **Army Research Labs**
  - PZT Coatings for MEMS devices -  
Dr. Madan Dubey

# UA new activities

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- MOU with JPL/Boeing/Honeywell
- satellite systems have similar needs
- look at “macro-MEMS” design (high accuracy, low-cost)
- shared intellectual property rights -  
UA special materials designs and  
JPL/industry commercialization

# Current Status - UA Research Element

- **MEMS materials research (UA - Tuscaloosa)**
  - proceeding under FY-99 and -00 FAA funds
  - FY-01 funding approved to continue
  - new MEMS fabrication lab and “clean room” to be completed and equipped Summer ‘02
- **IFOG characterization (UA - Huntsville)**
  - conducting technology feasibility study
  - investigating low-cost (single mode) fibers
- **Analysis, Test, and Simulation**
  - established multiprocessing computer lab
  - electronics packaging for prototype



# UA R&D Time - Task Schedule

[illegible]

# NAS Planning Study

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- **BAE Systems - FAA SETA contractor**
- **Requirements assessment**
- **future “Concept of operations”**
- **NAS Plan integration issues**
- **Sustainable Research Program**
- **work in progress - Terry Pearsall (BAE) and Bob Lilley (Illgen)**

# GPS/INS Integration Study

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- Avionics Engineering Center at Ohio University
- PI: Frank van Grasse
- work in progress: implementation & integration issues
- following RTCA SC-159 Working Group activities

# Integration of GPS and INS

- **Capitalize on attendant advantages of independent systems**
  - improvement in accuracy, availability, integrity, reliability
  - complimentary for system robustness
- **Provides redundancy/safety backup**
  - allows GPS as sole means of navigation
- **Allows savings through reduced cockpit avionics**

# SBIR (Phase 1) - Cybernet

- Research topic: multi-sensor and optical sensing for independent position and navigation; flight test
- Pls: George Paul
- work in progress

# SBIR (P1)- Paper Pilot Research

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- **Research Topic: algorithm for dead-reckoning navigation using a priori aircraft state**
- **PI: Mark Anderson**
- **work in progress**

# SBIR (P1) - Sierra Nevada Corp

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- Research topic: machine learning & information processing for enhanced MEMS performance
- PI: Ian Gallimore
- work in progress
- (paper in this session)

# Future ANS Program Planning

(high order goals)

- **Identify technology gaps**
- **Address needed R&D**
- **Develop requirements and standards**
- **Develop operating scenarios**
- **Integrate requirements with NAS Plan**
- **Coordinate with other agency programs (NASA, DARPA)**



# Goals for a robust ANS Program

(Capability-Safety-Cost)

- Enable early transition to “sole-source” GPS navigation for General Aviation by affording safety back-up system
- Improve safety by providing pilots a more robust and reliable system for enroute navigation and terminal operations
- Reduce FAA maintenance/operating costs by early retirement of legacy navigation and landing systems

# Next Steps

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- Continue UA research on existing \$
- Look at SBIR prospective outcomes
- Search for funding to build program-level effort, based on BAE study
- Consider prospects for affordable GPS/INS solution, based on OUAEC study

# The End

- Thank you for your attention and interest